July 15, 1947. H. SNOW ET AL 2,423,910

WOVEN FABRIC

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Fig. 1.

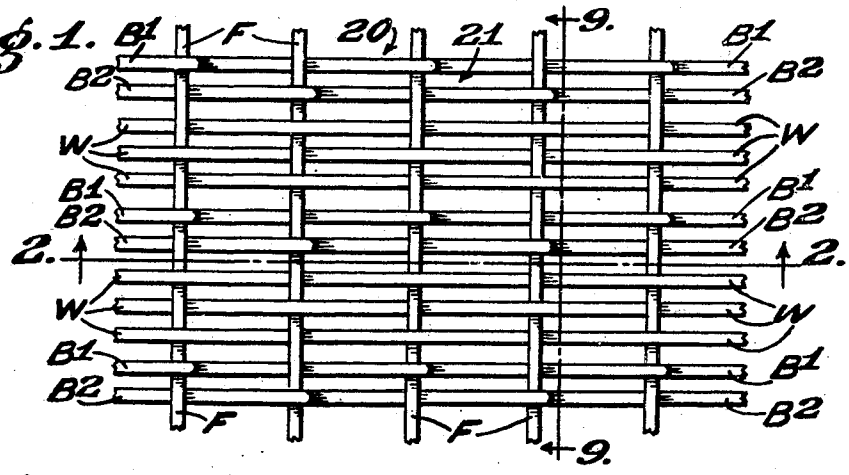


Fig. 2.

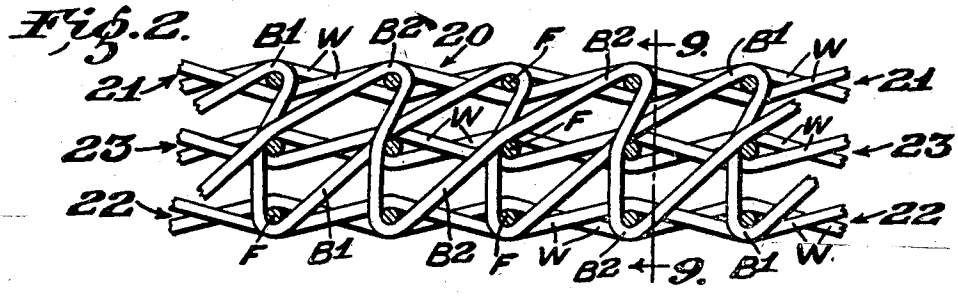


Fig. 3.

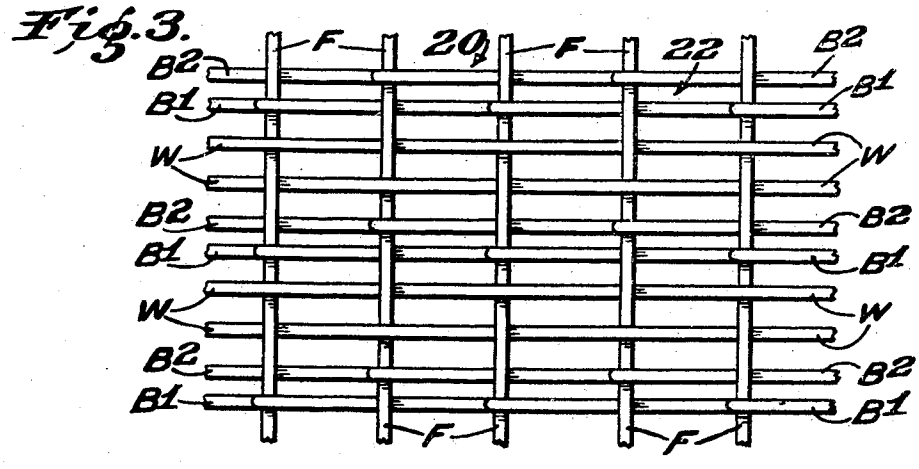
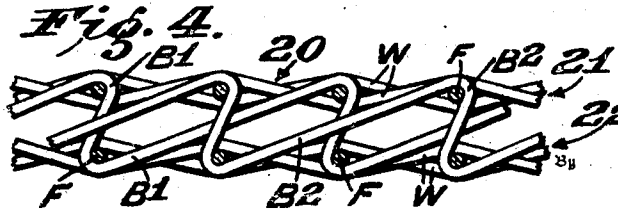


Fig. 4.



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WOVEN FABRIC

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Fig. 5.

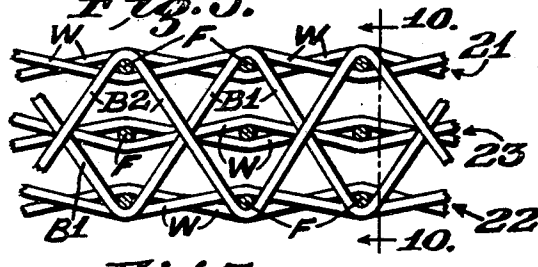


Fig. 6.

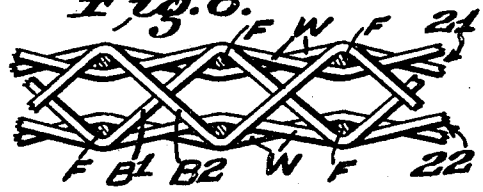


Fig. 7.

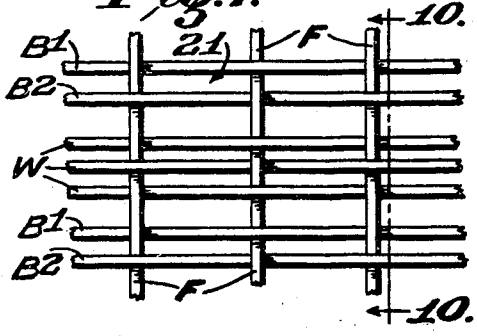


Fig. 8.

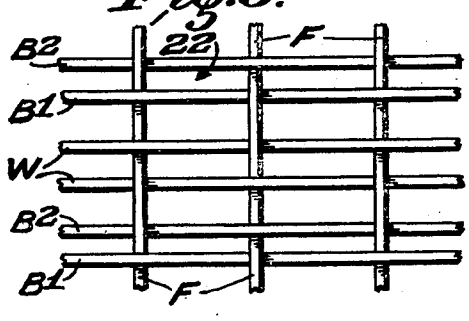


Fig. 9.

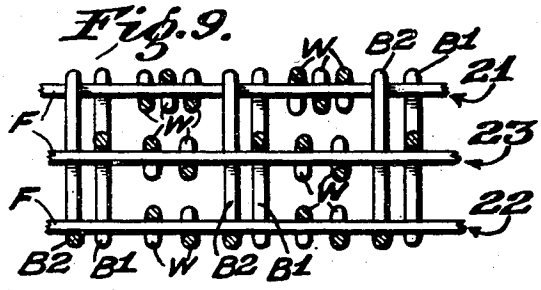


Fig. 10.

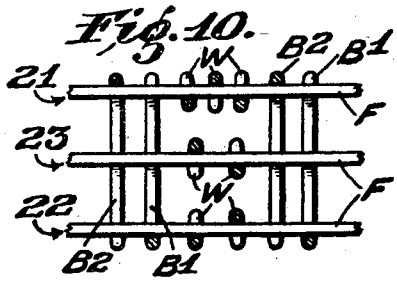


Fig. 11.

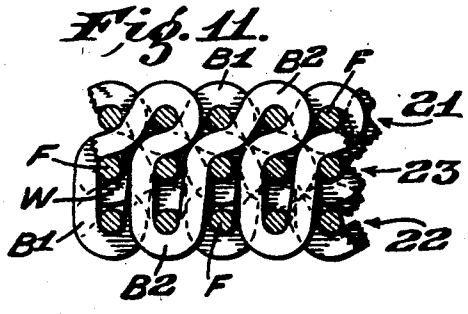
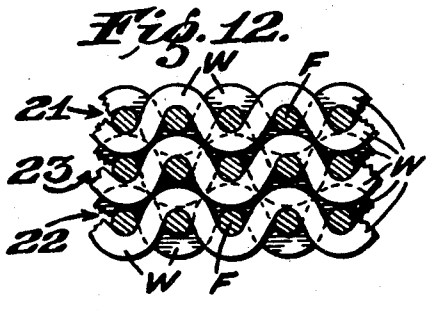


Fig. 12.



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WOVEN FABRIC

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Fig. 13.

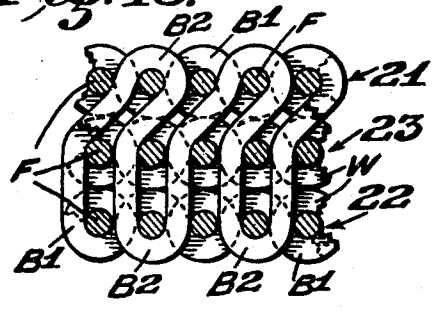


Fig. 14.

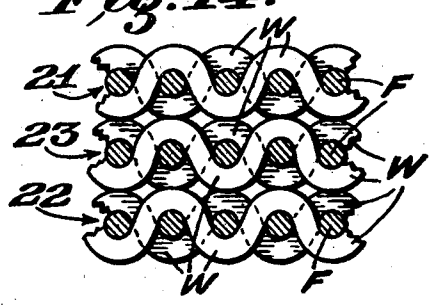


Fig. 15.

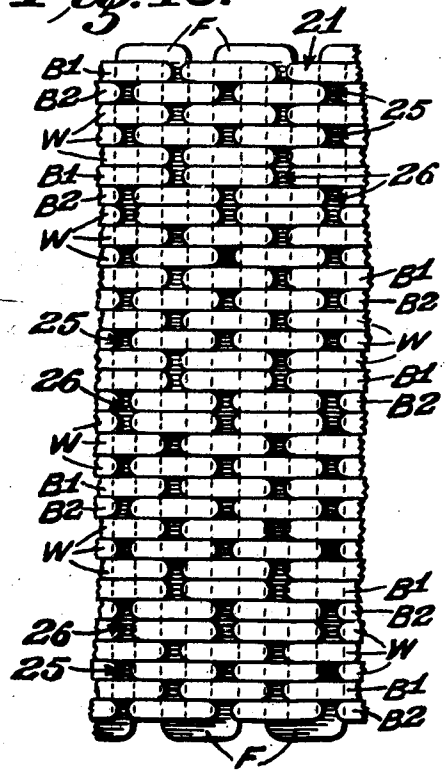


Fig. 17.

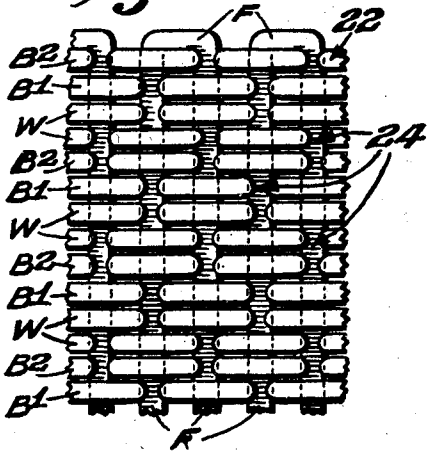


Fig. 18.

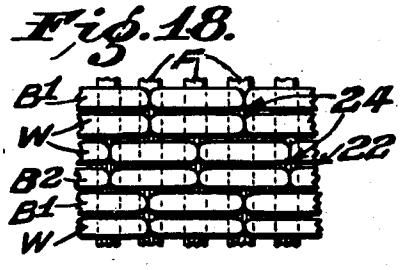


Fig. 19.

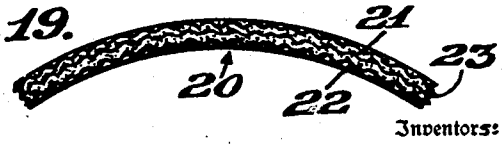
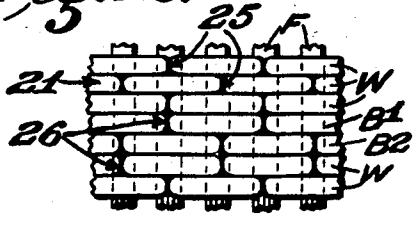


Fig. 16.



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UNITED STATES PATENT OFFICE

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WOVEN FABRIC

Howard Snow and Eugene A. Gulledge, Charlotte, N. C., assignors to Southern Friction Materials Company, a corporation of North Carolina

Application April 26, 1944, Serial No. 532,850

5 Claims. (Cl. 139—409)

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This invention relates to woven fabrics and more particularly to a fabric woven from asbestos yarn, either plain or metallic reinforced, or other suitable threaded material, or a combination of different such materials, into a multi-ply sheet, strip or tape for use as a brake lining, belting, or the like.

For some uses, brake linings in particular, the woven fabric is afterwards chemically treated, usually by impregnating the same with an organic material of a thermosetting character, the aim being to give requisite frictional quality, strength and durability to the product as a whole without unduly stiffening the same or detracting from the possibly limited, though generally inherent, flexibility thereof. The face or faces of the woven and chemically treated fabric are then usually ground to eliminate any existing incrustation and produce an even surface so as to enhance its frictional and tractive quality as a brake lining without any appreciable weakening of the fabric. This is the ideal sought, but practical difficulties (two fundamentally in particular) have arisen heretofore in the manufacture of brake linings and the like:

Firstly, since the fabric as woven originally is formed flatwise in one plane, but in use has to be curved arcuately in segments out of that plane to a form corresponding to the curvature of the brake drum or member on which the fabric is applied, there has been a tendency heretofore towards a concavo-convexing deformity transversely of the lining. This has been due principally to the uniform ratio of the yarn in the outer or top ply and the inner or bottom ply in the original straight-plane form of the fabric, whereby when the fabric is curved arcuately, the inner or bottom ply becomes too dense as compared to the density of the outer or top ply. Thus, the aforesaid transverse deformity is caused due to the resulting unequal densities in the two opposing surfaces of the fabric. In the arced form of the fabric, heretofore, there became a decrease in density of the outer or top face ply where maximum density is needed most, and a substantial compacting and increase in density of the inner or bottom face ply where it is needed the least. One serious disadvantage of this is, that in addition to the reduction in density of the outer or top face portion of the lining, the said concavo-convex deformity necessitates excess grinding of the outer or top face in particular to level the same off, thereby not only lessening the thickness of the lining greatly but also weakening the structure appreciably due

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to resultant cutting away and rupturing of the exposed portions of the woven threads, which is rendered unnecessary by the present invention. The same is true as to the inner or back face of the fabric.

Secondly, since a major objective is a smooth, well-filled surface on both sides of the lining, manufacturers have resorted to many expediencies, all of which have their limitations. Some manufacturers have introduced inorganic fillers suspended in an emulsified pretreatment by applying it to the yarn just before weaving. This procedure does a remarkably good job of filling up the holes in the weave but is sloppy, annoying to the weavers, and hard on the equipment. Other manufacturers have resorted to high compression such as obtained in a hydraulic press in their effort to fill up the holes in the weave. But this procedure has the double disadvantage of being expensive and of breaking some of the fibers. Still other manufacturers have sought a solution by making no effort to cover the filling completely with warps, but instead, they have reeded the warps out to the point where the filling rises to the surface from pressure by warps below it. The filling is then said to be "crimped." Such a procedure precludes the extra wear afforded by the surface warps and also generally results in a rather low density fabric.

A satisfactory solution to the above noted problems of long standing in the industry is found in the present invention which consists primarily in a novel fabric weave of a peculiar character, i. e., a multi-ply fabric is produced, having in its normal, original flat-woven form, an outer or top ply comprising a given number of warp threads per dent and an inner or bottom ply comprising a proportionately lesser number of warp threads per dent, the parallel warp threads of each ply being carried sinuously and alternately over and under adjoining transverse filler or weft threads, so that, when finally tightened to the desired degree in weaving, and the form of the fabric is in a straight, flattened plane, the outer or top ply is relatively denser than the inner or bottom ply, but when the fabric is afterwards arced or bowed for use as a brake lining the outer or top portion is placed under tension longitudinally and accordingly stretched slightly and the inner or bottom portion is correspondingly placed under compression longitudinally and compacted slightly, thereby approximately equalizing the density at both sides of the fabric, yet leaving ample density in the outer or top face portion. At the same time all tendency to concavo-convex de-

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formity transversely of the material is obviated. So, too, a regular uniformity in design of weave formation is produced on the inner or bottom face of the fabric with a somewhat irregular or uniformly non-uniform design on the outer or top face, yet there is symmetry in the designs of both faces. So, too, there is an appreciable minimization in number and size of surface cavities or pits as well as internal interstices throughout the body of the weave to be filled in by the impregnating material generally used in the chemical treatment of the fabric for brake linings and the like.

In the course of our experiments we have found that all of the aforementioned obstacles can be overcome by the application of a 5/4 ratio between top and bottom ply yarns (including all yarns appearing on the surface—i. e., warps and binders) in a regular double binder multiple ply weave. Or, stating it in another way (without reference to the binder threads, but only as to the warp threads of the top and bottom plies) the ratio is what may be termed a "three-two" instead of a "five-four" weave, i. e., three warp threads to each dent in the weaving of the outer or top ply and two warp threads to the same dents for the inner or bottom ply. In this connection, it is here noted that all reference throughout this specification, to thread ratio and relative density in the weave applies only or in particular to the main body of the opposite face plies of the fabric crosswise or transversely thereof and exclusive of the extreme marginal portion or selvedge of the fabric.

A 6/4 ratio favors the top ply beyond practical utility. A 4/4 ratio, of course, doesn't favor the top ply at all. This invention is, therefore, limited to weaves of the 5/4 ratio or ratios very closely approximating the same.

A first practical requirement for a multiple ply weave for woven asbestos brake linings in particular is that it be applicable to commercial yarns which are of such size as to demand reeds with 4 through 8 dents per inch. This 5/4 weave is particulary suited to this range.

A second practical requirement of a multiple ply weave for brake linings is that its surfaces be uniform and symmetrical. The present invention achieves this completely on the bottom face where the pattern is a straight two ends up, two ends down; and achieves it on the top face where the pattern is one end up, one end down for six longitudinal surface yarns counted across the weave, followed by two up, two down; after which the sequence is repeated.

A third requirement is that there be a fairly high ratio of binders (yarns that go through the fabric from surface to surface) to warps so as to prevent ply separation.

The present invention is the only weave, of which we are aware, affording a 5/4 ratio in the practical limits of commercial asbestos yarn multiple ply weaving; affording symmetry on both sides of the fabric; and having an adequately high binder-to-warp ratio.

The above-noted illustrative and preferred weave is set forth in detail in the following description in conjunction with the accompanying drawings, in which:

Fig. 1 is a top plan view, more or less diagrammatic and in an open form, illustrative of the preferred fabric weave;

Fig. 2 is a vertical section taken on the line 2—2 of Fig. 1;

Fig. 3 is a bottom plan view of the weave illustrated in Figs. 1 and 2;

Fig. 4 is a view similar to Fig. 2 but illustrating the same form of weave as used in a "two-ply" as distinguished from a "three-ply" fabric;

Fig. 5 is a view showing a different double binder form and arrangement in a "three-ply" weave;

Fig. 6 is illustrative of a "two-ply" weave with a double binder like that shown in Fig. 5;

Fig. 7 is a top plan view of the weave shown in Figs. 5 and 6;

Fig. 8 is a bottom plan view of the weave shown in Figs. 5 and 6;

Fig. 9 is a transverse vertical section taken on the lines 9—9 of Figs. 1 and 2;

Fig. 10 is a transverse vertical section taken on the lines 10—10 of Figs. 5 and 7;

Fig. 11 is a fragmentary, vertical, sectional elevation, on a magnified scale, the section being taken approximately on the line 2—2 of Fig. 1 and the illustration being similar to that in Fig. 2 except that the interwoven threads are drawn close together as in the actually formed fabric;

Fig. 12 is a view similar to Fig. 11 but showing only the warp and the weft or transverse filler threads;

Fig. 13 is a view the same as Fig. 11 except that the interwoven threads are not drawn as compactly together;

Fig. 14 is a view similar to Fig. 12 but showing the interwoven threads in the same degree of closeness as in Fig. 13;

Fig. 15 is a fragmentary top plan view of the woven fabric in the more or less diagrammatic but drawn-together form shown in Figs. 11 and 13;

Fig. 16 is a fragmentary plan view similar to that in Fig. 15 but simulating more nearly the exact appearance of the outer or top face of the actual fabric when woven and compacted tightly in accordance with the present invention;

Fig. 17 is a bottom plan view of the woven fabric in the more or less diagrammatic but drawn-together form shown in Figs. 11 and 13;

Fig. 18 is a fragmentary plan view similar to that in Fig. 17 but simulating more nearly the exact appearance of the inner or bottom face of the actual fabric when woven and compacted tightly in accordance with the invention; and

Fig. 19 is a fragmentary view, in the edge elevation, of a segment of brake lining constructed in accordance with the present invention and shown in arced form approximately as it is when attached to the brake drum or element in use.

Referring now to the accompanying drawings in detail, first more particularly to Figs. 1 to 4, inclusive, the numeral 20 designates, generally, a multi-ply woven fabric of the present invention intended more especially for use as a brake lining. Whatever the number of plies comprising the multi-ply fabric the same proportional warp and binder thread ratio is carried out in the outer or top face ply and in the inner or bottom face ply. The outer or top face ply of the weave is designated in the drawings by the numeral 21 and the inner or bottom face ply by the numeral 22.

In the instance of the fabric comprising three or more plies the intermediate ply or plies may be in substantially the same ratio as the inner or bottom face ply, or the same may be varied in number of warp threads different from said inner or bottom face ply, but in any case the bottom ply should have a lesser number of warp threads than the outer or top face ply of the fabric. In

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the illustrative drawings the intermediate ply is designated by the numeral 23.

In the drawings all warp threads are designated individually by the letter W; the weft or transverse filler threads by the letter F; and each companion pair of the double binder threads respectively by the symbols B^1 and B^2.

In the particular weave illustrated in the drawings the warp threads W of the top ply 21 and the bottom ply 22 are carried sinuously and alternately under and over the adjoining transverse weft or filler threads F in an unitary three-two ratio between dividing pairs of binder threads B^1, B^2, as hereinabove described, and the warp threads of the intermediate ply or plies (if any) are likewise carried under and over the weft or filler threads. Preferably, too, the binder threads in their doubled or paired companion relation are carried the one (B^1) over a weft or filler thread F of the top ply 21 of the fabric, thence down through the body of the weave, rearward of the next underlying weft or filler thread or threads (if the fabric be of three or more plies) and under the underlying weft or filler thread of the bottom ply 22, thence returned up through the body of the weave and forwardly over the second adjacent weft or filler thread of the top ply, and so on throughout the length of the weave. The companion thread (B^2) of each pair of binders is carried in a like tortuous manner but in a staggered relation to the said thread B^1, i. e., forwardly under and over each alternate second adjacent weft or filler thread F of the top and bottom plies 21, 22 (see Figs. 2 and 4).

Instead of the binder arrangement and relation just above described, a conventional, zigzag, double binder construction and arrangement as illustrated in Figs. 5 and 6 may be used. In this form the binder thread B^1 is carried alternately over a weft or filler thread F of the top ply 21 and thence forwardly down diagonally and under the next adjacent weft or filler thread ahead thereof in the bottom ply 22, and from there up and forwardly over the second adjacent weft or filler thread of the top ply 21, and so on. The binder thread B^2 is carried likewise throughout the length of the weave but alternately under and over the weft or filler threads of the top and bottom plies 21, 22, in a staggered relation to the tortuosity of the companion thread B^1. In this type of double binder the threads B^1 and B^2 extend in criss-cross fashion between the respective weft or filler threads F instead of substantially straight down behind alternate ones of the weft or filler threads F of the intermediate ply or plies throughout the length of the woven fabric as shown in Figs. 2 and 4.

The form of double binder illustrated in Figs. 2 and 4 has been found most satisfactory in commercial practice of the present invention because it combines with the characteristic ratio (especially the "three-two" ratio) of the warp thread arrangement to produce a woven fabric of ample density in the inner or bottom face portion, without any excess or detrimental crowding of the middle internal portion of the fabric.

The general longitudinal and transverse form and arrangement of the warp, weft or filler, and binder threads of the weave in accordance with the inventive idea is exemplified more clearly in the diagrammatic, open-form of illustration in Figs. 1 to 10, inclusive. It is also apparent in the magnified showing of the interwoven threads of the fabric drawn into close relation to each other in Figs. 11 to 15, and 17. A more nearly exact simulation of the appearance of the outer or top and the inner or bottom faces of the actual fabric is illustrated in Figs. 16 and 18, respectively.

It is here noted that, for a brake lining, the threads used generally are of asbestos yarn, either with or without wire reinforcement, and the same usually are woven while in a dampened condition. This, of course, makes the threads more readily deformable and conformable in the desired shaping of the woven fabric. That is to say, after weaving, and while the fabric is still in a moistened condition, the sheet, strip or tape, as the case may be, is readily affected by minimum external pressure and manipulation to flatten appreciably such numerous surface protuberances as those naturally presented by the exposed portions of the warp threads W and the binder threads B^1, B^2 that cross over the respective weft or filler threads F of the face plies 21, 22 of the fabric. Thus, a satisfactory levelling off of the surface is easily and practically attained, and the flattening deformation not only appreciably decreases and minimizes the size of all surface protuberances but also causes a lateral and longitudinal spreading of the individual threads which substantially fills in and obliterates or at least minimizes the number and size of all surface cavities, pits or interstices.

Such surface cavities that do remain prior to chemical treatment or impregnation of the fabric become filled with the treating or impregnating material and any resultant incrustation is readily removed from either or both surfaces of the prepared fabric and a levelling of the surfaces is effected without any appreciable cutting or rupturing of the exposed threads of the weave. In this connection, also, it is here stressed that the avoidance of the tendency of transverse concavo-convex deformity when the woven fabric is bent or arced longitudinally is an important advantage achieved in the peculiar thread ratio of the outer or top and the inner or bottom plies of the fabric of the present invention, in addition to minimization of surface cavities.

The prevention of transverse curvature or concavo-convexity and elimination of the holes enables minimum surface grinding and avoids appreciable lessening of thickness and weakening of the brake lining.

In most forms of brake linings for which the characteristic weave of the present invention is used, the threads are usually of asbestos yarn and usually, too, all of the yarn or other threads are of substantially the same size or gauge individually, and the fabric is woven in the hereinabove described "three-two" ratio as to the warp threads alone or the "five-four" ratio when including a companion pair of the binder threads as a unit in the respective outer or top face and inner or bottom face plies of the fabric. The invention, however, is not limited positively to such specific kind or size of threaded material. It includes the use of other fibrous material, both natural and synthetic, such as extruded plastic material, nylon, rayon, etc., and even such metallic elements that are approved and used in connection the fibrous elements in some brake linings. In all cases, however, a close approximation of the herein described weave ratio in the outer or top face ply and the inner or bottom face ply of the fabric is essential for the desired effect in accordance with the invention as set forth herein.

As to the hereinbefore mentioned "regular uniformity" in design of the inner or bottom face of the woven fabric and the "irregular or uniformly

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non-uniform" design of the outer or top face of the same, illustrative reference is here made to Figs. 15 to 18, inclusive, and more particularly Figs. 16 and 18 which show a more nearly exact picturization of the surface appearance of the actual fabric.

By referring to the illustration of the inner or bottom face of the fabric in Fig. 18, it is noted that there is sameness in regular uniformity throughout the entire face in that there are correlated companion pairs of warp threads W and binder threads B^1 and B^2, respectively, the exposed loops of each companion pair of threads meeting close together longitudinally throughout the length of the weave and only affording possibly slight cavities or pits in the surface to be filled in by the chemical treating or impregnating material. These incidental cavities or pits are each of a size transversely of the weave substantially equal to the width of the two companion surface-exposed warp and binder threads, as indicated at **24** in Fig. 18, and the several cavities or pits **24** are staggered uniformly throughout the said inner or bottom surface of the fabric. This is brought about by the "two-and-two" arrangement of the warp and binder threads in the ply **22** of the fabric.

By referring to the illustration of the outer or top face of the fabric in Fig. 16, the hereinbefore stated irregular or uniformly non-uniformity of design is noted. It will be observed more clearly in the open-form illustration of the full width of the fabric in Fig. 15, that adjacent each side margin or selvedge and at intervals transversely of the fabric, there are uniformly staggered cavities or pits **25** at the meeting of the exposed loops of single lines of the warp and binder threads; and between these longitudinal groups of staggered, single-thread-width cavities or pits **25**, there are two adjoining, longitudinal, parallel rows of double-thread-width cavities or pits **26** which, in their particular, staggered, paired relation, are uniformly staggered in their own grouping. This transversely alternate single and double row grouping of the surface-exposed thread loops as staggered in each group and the respective parallel groups being staggered in relation to each other, gives rise to the descriptive expression "irregular or uniformly non-uniform" as distinguished from "regular uniformity" of design of the opposite face of the fabric. Fig. 16 shows a fragment of the fabric in more compact and nearly exact simulation of the surface appearance of this outer or top face of the fabric as previously stated above.

The particular surface design of the outer or top face ply of the fabric as hereinabove described and illustrated in Figs. 15 and 16, is brought about by the special relative alternate arrangement of the warp threads W as illustrated more clearly in diagram in Fig. 1, wherein it is noted, by reading from top to bottom and from left to right of the illustration, that next adjoining the topmost pair of binder threads B^1, B^2, the three warp threads W are, in the set they comprise, carried alternately under and over the weft or filler threads F, and the set of warp threads W adjoining the next adjacent pair of binder threads B^1, B^2, are carried oppositely over and under the respective weft or filler threads F. This reverse weaving of the sets of three warp threads, separated by the respective pairs of binders threads (each pair in a duplicated weaving thereof) is carried out throughout the width of the fabric and thus creates the above described design of the outer or top ply of the fabric.

In Fig. 9 there is an opened, diagrammatic illustration in cross section of the said "three-two" or "five-four" (whichever way it may be termed) scheme in the weave as exemplified with the particular form and arrangement of double-binder threads as in Figs. 1 to 4, inclusive.

In Fig. 10 the cross sectional showing is of the same warp thread arrangement as in Figs. 1 to 4, inclusive, but with the double-binder thread form and arrangement as in Figs. 5 to 8, inclusive.

When the several threads of both of the weaves illustrated in cross section in Figs. 9 and 10, are drawn together to the desired degree of tightness in the woven fabric, the different plies, **21**, **22** (and **23**, if any) have their meeting threads intergaged intimately so as to create ample compactness of the fabric body without taking from the proportionate densities desired in the outer or top face ply and in the inner or bottom face ply of the fabric which is attained by the herein described specific warp and binder thread ratio in particular.

In final summarization, it is here stressed that there is dual advantageous effect in the novel proportionate thread content and density of the opposite face plies of the woven fabric, to wit: minimization or substantial elimination of surface cavities or pits, and avoidance of medial internal crowding of interwoven threads in the fabric body, with an ideal production of greater density in the outer or top face ply and a proportionately lesser density in the inner or bottom face ply, whereby arcuate flexing of the fabric longitudinally of the weave for brake lining purposes and the like creates a substantially equalized density in both of its face portions, and at the same time the peculiar manner of weaving effectively avoids and eliminates all tendency to any concave-convexity crosswise or transversely of the weave.

While the fabric of the present invention is primarily intended for brake linings, it is equally applicable to belting and other analogous uses where the same basic requirements exist and the same advantages are to be attained. So, too, the relative size and number of threads in the outer or top ply and the inner or bottom ply of the fabric may be varied within the purview of the invention if producing the same relative densities in the said opposed face plies approximating that produced by the herein above described 5/4 or 3/2 ratio in the weave.

What is claimed is:

1. A multi-ply, double binder, woven fabric having ends in the top and bottom ply in the ratio of five to four, the bottom ply being symmetrical and having adjacent warp and binder yarns which rise and fall together and thereby equalize tension in the bottom ply, successive pairs of double binders being together, and the number of warps being at least double the number of binders.

2. A multi-ply, double binder, belting weave having five ends on the top surface to four ends on the bottom surface with a warp and a binder rising and falling together in the bottom ply, successive pairs of double binders being together, and certain of the warps in the top ply rising and falling with an adjacent binder and other warps in the top ply disposed oppositely to adjacent binders.

3. A multi-ply, double binder, belting weave

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having five ends composed of three warps and two binders on the top surface, to four ends composed of two warps and two binders on the bottom surface, with bottom ply warps rising and falling with their adjacent binders, successive pairs of double binders being together, but only certain of the top ply warps rising and falling with adjacent binders, and other warps in the top ply disposed oppositely to adjacent binders, the lack of symmetry in this product being placed on the overloaded top surface and thereby minimizing the overall effect of dissymmetry in the product.

4. A multi-ply woven fabric having a top ply in which warp ends in sets of threes correspond to warp ends in sets of twos in a bottom ply and any intermediate plies, said sets of warp ends being spaced between binders uniting the plies of said fabric, certain of the warps in the top ply rising and falling with an adjacent binder and other warps in the top ply disposed oppositely to adjacent binders, and the bottom ply being symmetrical and having adjacent warp and binder yarns which rise and fall together and thereby equalize tension in the bottom ply.

5. A multi-ply woven fabric having a top ply in which warp ends in sets of threes correspond to warp ends in sets of twos in a bottom ply and any intermediate plies, said sets of warp ends being spaced between binders uniting the plies of said fabric, certain of the warps in the top ply rising and falling with an adjacent binder and other warps in the top ply disposed oppositely to adjacent binders, and the bottom ply being symmetrical and having adjacent warp and binder yarns which rise and fall together and thereby equalize tension in the bottom ply, the lack of symmetry in said woven fabric being placed on the overloaded top ply thereby minimizing the overall effect of dissymmetry in the fabric.

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